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HIGH TEMPERATURE THERMOCOUPLE INSTALLATION METHODS FOR HYPERSONIC VEHICLES

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Structures Division

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Interim Report

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14. ABSTRACT
This presentation discusses the joint effort between the Air Force Research Laboratory (AFRL) and NASA Langley Research Center to establish a process for bonding type C and type K thermocouples to high temperature materials. Bonded samples of both type C and type K thermocouples will be tested in a combined thermal-vibration environment. A baseline and alternate installation method will be tested. The instrumented specimens will be mounted on a shaker and heated with quartz lamps. The specimens will be exposed to three different environments: a launch vibration spectrum, a re-entry vibration spectrum, and a high temperature degradation environment. The installation methods that are capable of withstanding these three environments will be considered for use in hypersonic flight testing.

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instrumentation, thermocouples, hypersonic vehicle, high temperature, thermal vibration testing

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AFRL

THE AIR FORCE RESEARCH LABORATORY

LEAD I DISCOVER I DEVELOP I DELIVER

High Temperature Thermocouple Installation Methods for Hypersonic Vehicles

American Institute of Aeronautics and Astronautics (AIAA) Dayton-Cincinnati Aerospace Sciences Symposium

4 March, 2008

John Feie

Air Vehicles Directorate

US Air Force Research Laboratory

AFRL/RBSA, Wright-Patterson AFB, Ohio

Introduction

- Hypersonic Vehicle History and Background
- Air Force Performance Goals
- Hypersonic Vehicle Thermocouple Instrumentation History and Limitations
- Recent Thermocouple R & D at the AFRL
- Verification and Testing of TC Installation Methods
- Results and Conclusions

Hypersonic Vehicle Thermal Structures Test Challenges

- Air Force Requirements for Hypersonic Vehicles
  - Space Access
  - Hypersonic Cruise
- High Speed = Extreme Environment
  - Acoustics
  - Heating
  - Flight Loads
- Extreme Environment = Advanced Materials & Structures

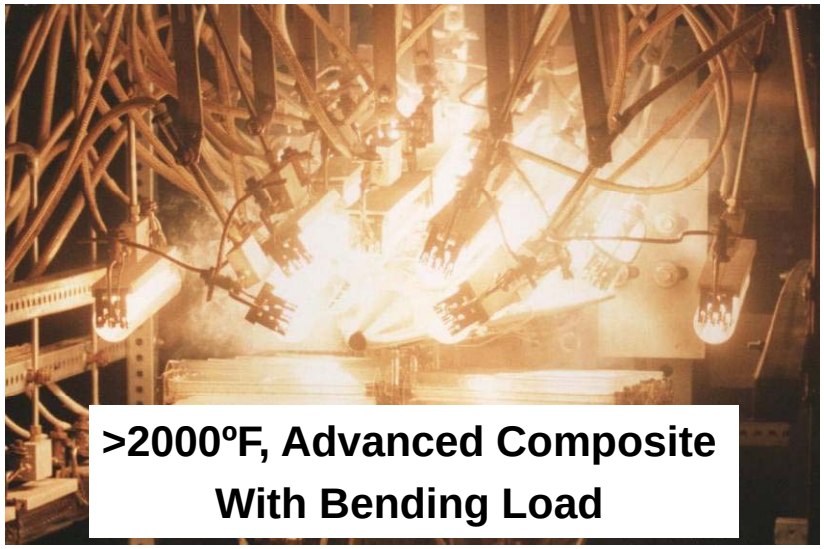
Hypersonic Vehicle Thermal Structures Test Challenges

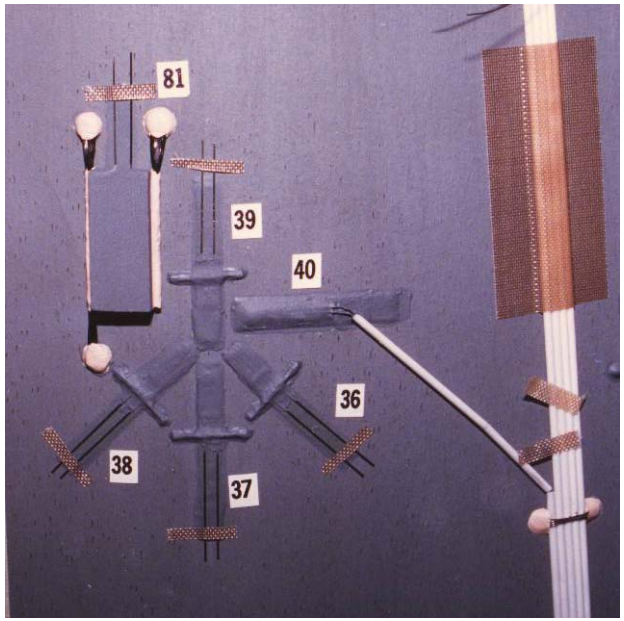
Performance Goals

Hypersonic Vehicle Thermal Structures Test Challenges

Instrumentation Difficulties

- Temperature Capability
- Attachment Methods
- Specimen Compatibility
- Compatibility with Loading Systems

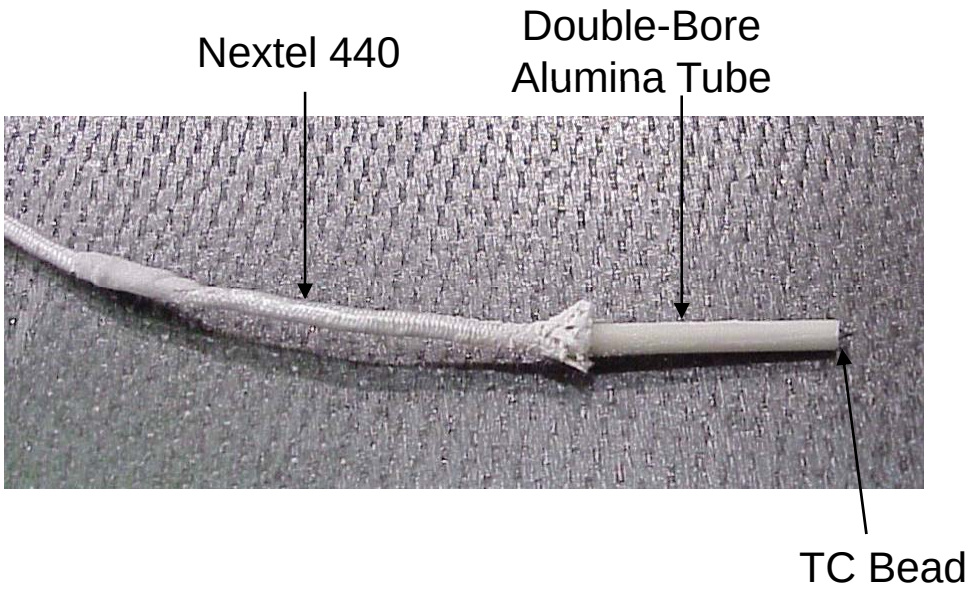




- Instrumentation did not adhere
- Sheath/Lamp arcing
- Emissivity change
- Coating damage

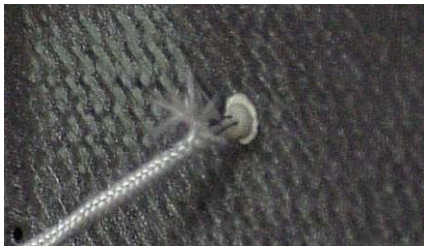
Carbon-Carbon Thermocouple Surface Installation

- **Surface TC's mounted through-the-thickness of aeroshell**
- **Type C, Nextel 440 insulation**
- **TC is potted at surface with ceramic cement**
- **Thermocouple mounting procedure successfully developed and tested to >3000°F in a 1 inch thick C-C specimen at AFRL**



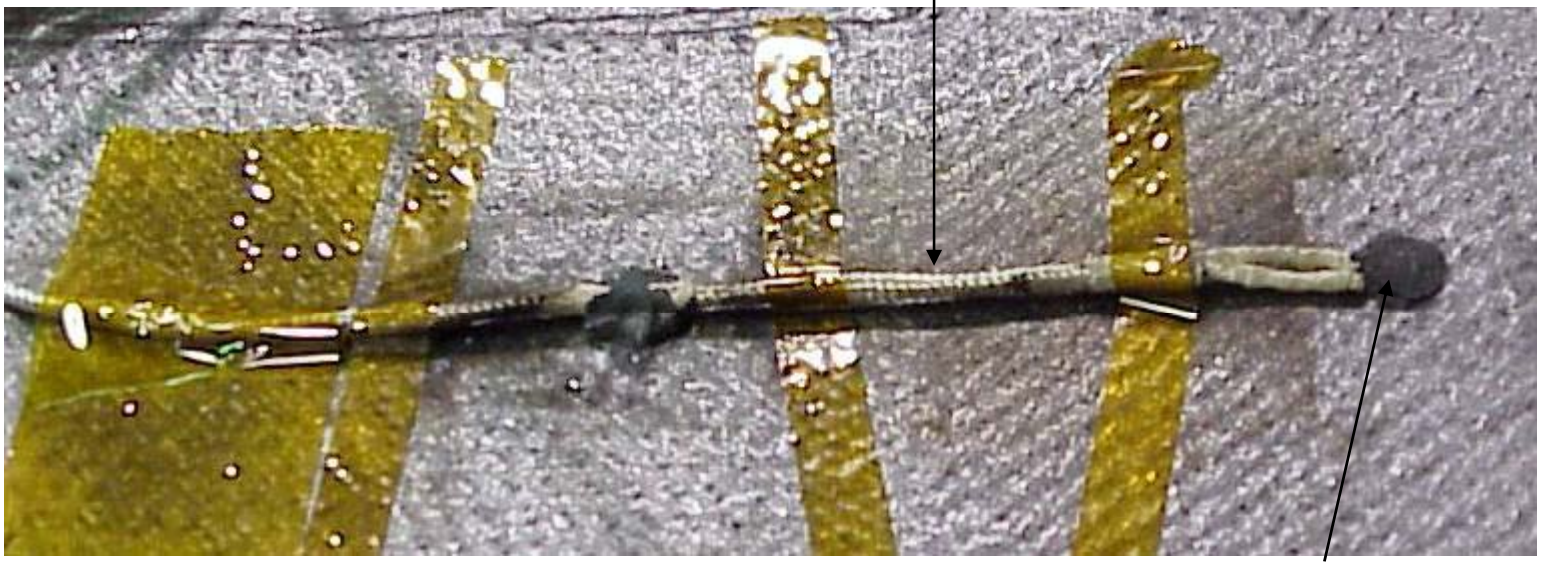
TC potted slightly below C-C Surface
(to be covered with graphite)

Surface TC also potted at backface

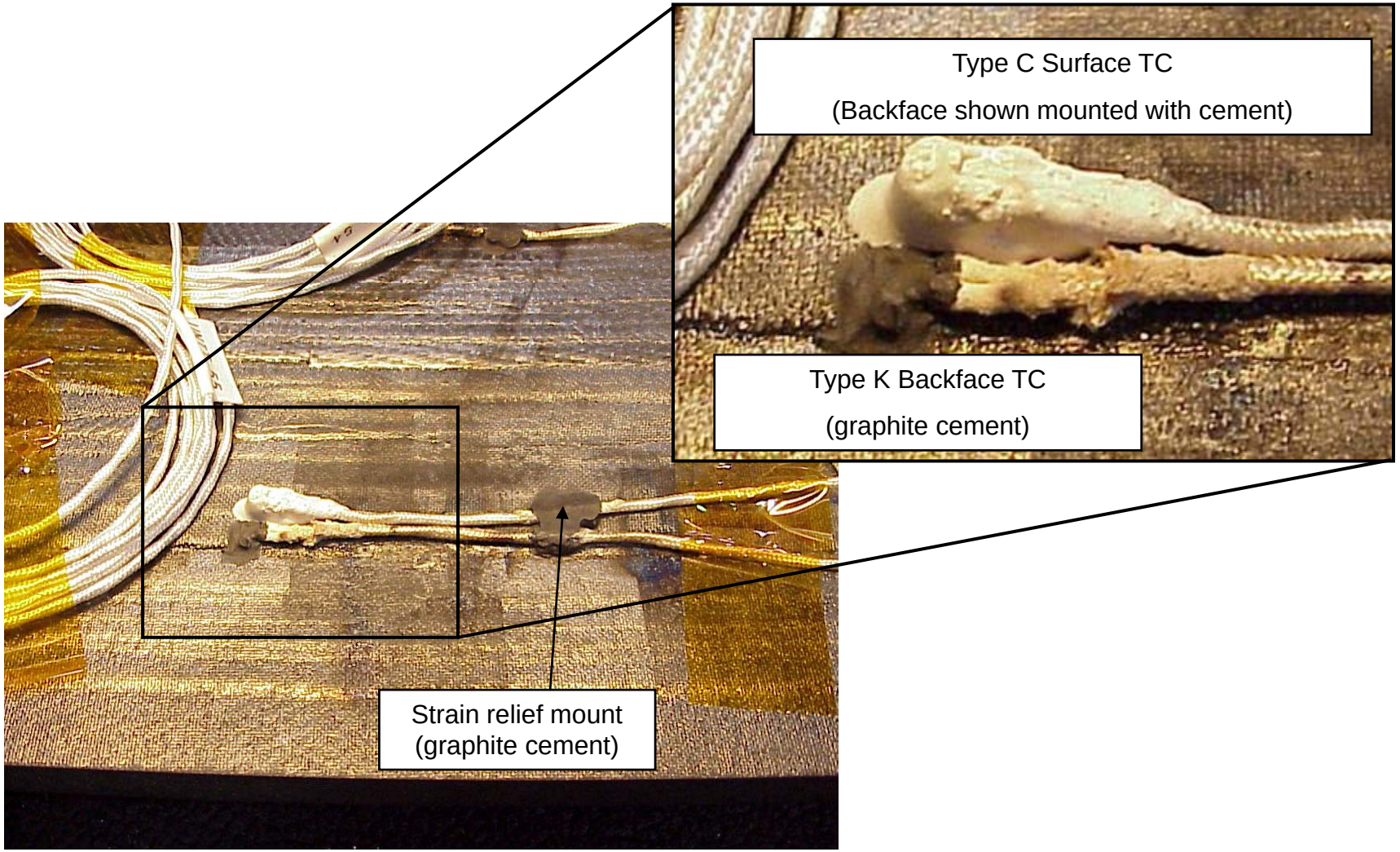


Carbon-Carbon Thermocouple Surface Installation

- **Backface TC's mounted to aeroshell surface**
- **Type K, Nextel 312 insulation**
- **Thermocouples mounted using graphite cement**
- **Thermocouple mounting procedure successfully developed and tested at AFRL**

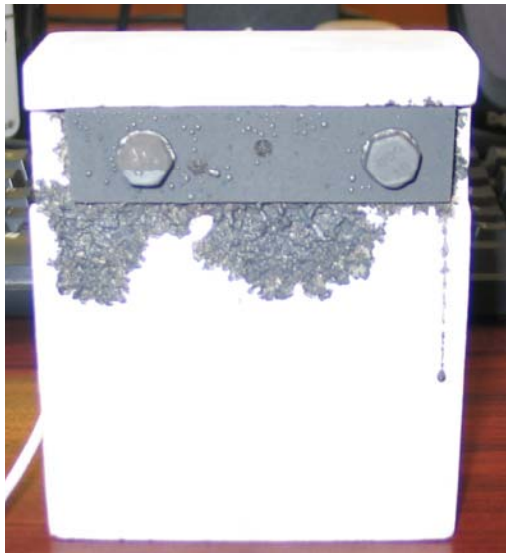


Thermocouple Mounting



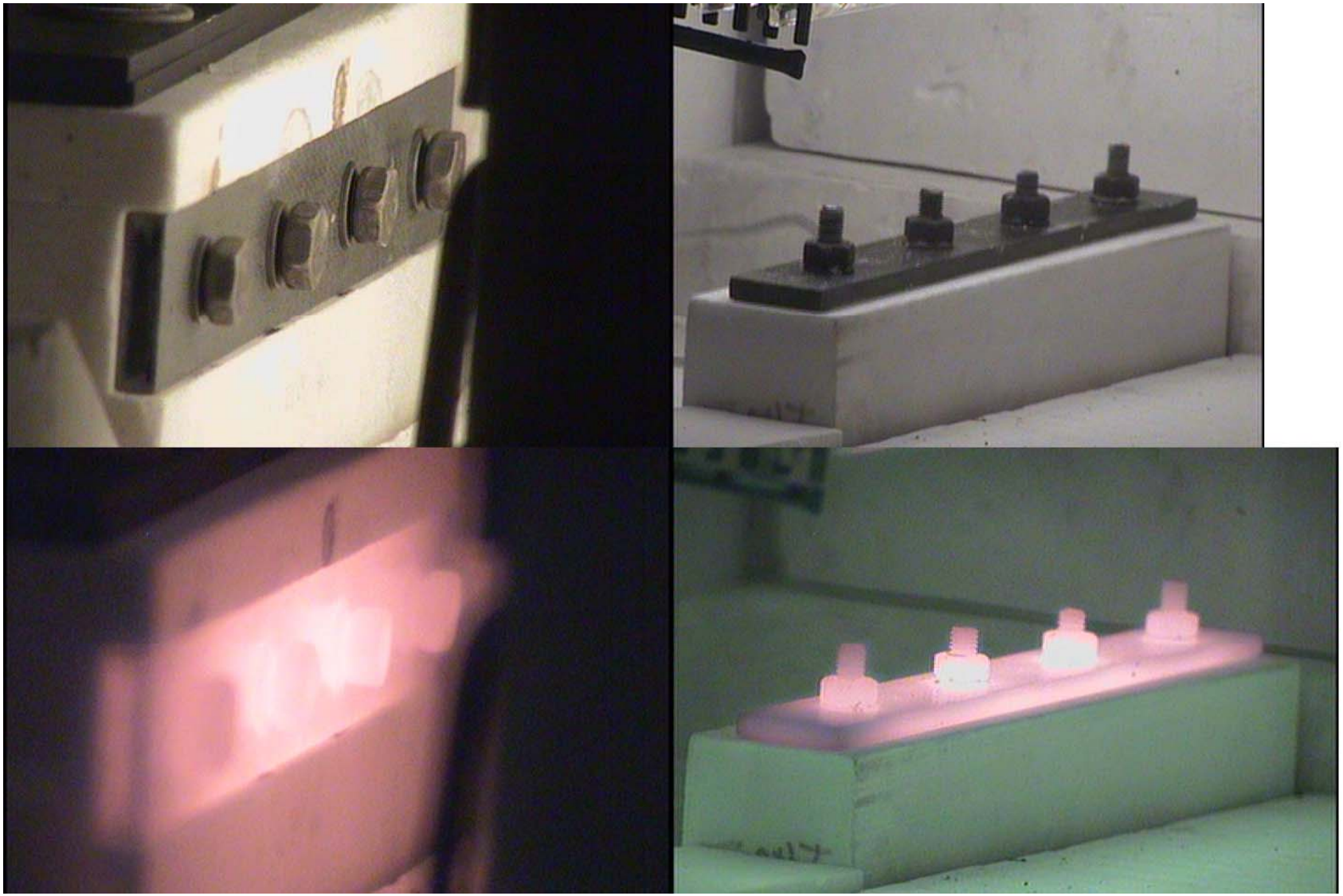
Verification of TC Installation Methods

- Quartz lamp heaters used to simulate thermal environment (> 2000°F)
- Specimen mounted to shaker to simulate vibration environment (> 15 g's)
- Insulation needed to keep shaker head near room temperature
- 3" and 8" coupons tested
- Thermocouples imbedded into coupon and backfilled with graphite cement



- Coated specimens failed, due to melting of coating
- Melted, corrosive coating attacked the insulation requiring the test to be aborted

Thermal Vibration Testing



Results and Conclusions

- **Hypersonic vehicle flight involves extreme thermal and vibration loads**
- **Extreme environment and advanced materials require development of new methods for instrumentation installation**
- **High temperature cements offer potential solution**